

Occurrence and Distribution of Bees (Hymenoptera: Apidae) of Public Health Importance on the Island of Oahu

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Abstract. The Vector Control Branch of the Hawaii State Department of Health has accumulated a large volume of written inspection data on pests of public health for the island of Oahu. Bee complaints provided the fourth greatest amount of arthropod pest information available, following mosquito, other fly and flea complaints. The objectives of this study were to conduct a survey of the occurrence of bee complaints on Oahu over a 10 year period, determine their distribution over time, graphically compare bee occurrence within and between district/areas, and correlate bee occurrence and distribution with season. Bee data were drawn from inspection reports from 1990–1999, population information was obtained from Hawaii Census and State of Hawaii Data Books, 125 district/area geographic locations were defined, and bee occurrence and distribution were adjusted for population and mapped using ArcView GIS 3.2. Reported bee activity was found mostly within the central, south and east urban districts. The eastern half of south Oahu and the southern half of the east districts showed the highest number of complaints. The levels of bee activity were highest during the spring, summer and fall, and there were bee problems around the airport throughout the year. The primary bee species recorded was *Apis mellifera* Linnaeus, the honey bee. The main sources of bee problems were *A. mellifera* swarms, and bee hives established in urban areas from wild or domestic hives. Bee activity regularly occurs in urban areas as a result of past and present human activities. As a result, injury from bee stings is possible, especially in the eastern half of south Oahu and the southern half of the east districts from spring through fall when swarming activity is highest. The results indicate that educational programs should be carried out in late winter, and that residential bee surveys may be concentrated in a limited number of district/areas.

Key words: Bees, *Apis mellifera*, *Xylocopa sonorina*, public health, vector control, Oahu, GIS

Introduction

The Vector Control Branch (VCB) of the Hawaii State Department of Health was created in 1970 with the merging of Rodent Control and Mosquito Control programs. The VCB is a statewide inspection, education, regulatory, prevention and control program primarily concerned with the vector-borne diseases of dengue fever, murine typhus, leptospirosis and West Nile virus. Vector Control Inspectors deal with other arthropods of public health importance in addition to insect disease vectors and vertebrate pests. As a result, the VCB has accumulated a large volume of mainly hand-written inspection data on pests of public health importance for the island of Oahu. The objectives of this study were to conduct a survey of the occurrence of public health arthropod pest problems on Oahu over a 10-year period (1990–1999), obtain a general list of arthropod related problems and determine their distribution over time, graphically compare pest occurrence within and between district/areas, correlate pest occurrence and distribution with season, and identify target areas for

more efficient application of prevention, control and education programs. We report here the results obtained for bees.

Bees of Hawaii. There are three species of bees that are of medical importance in Hawaii, they are *Apis mellifera* Linnaeus, the honey bee; *Xylocopa sonorina* (Smith), the Sonoran carpenter bee; and *Halictus* sp., the sweat bee (Komatsu 1982). The bee species usually encountered on Oahu, however, are *A. mellifera* and *X. sonorina*. The first introduction of *A. mellifera* into Hawaii arrived on Oahu in 1853 from Boston, Massachusetts in the form of two hives (Roddy and Arita-Tsutsumi 1997). However, the colonies reached the islands in poor condition and survived for only a short time before dying out. Another attempt was made about four years later and three hives of the dark, German honey bee, *A. mellifera mellifera*, arrived in Honolulu in November 1857 from San Jose, California. This time, the hives survived the voyage in good condition, were placed in Nuuanu Valley and became successfully established. The Italian honey bee, *A. mellifera ligustica*, was subsequently shipped to the islands in 1880 from Los Angeles via San Francisco and became established as well. *Xylocopa sonorina* was abundant on the lowlands of Hawaii (Perkins and Forel 1899) prior to 1899. It was unknown until long after the islands were settled by foreigners, but was introduced well before 1883 and probably was imported by man in lumber from the warmer parts of America (Perkins 1913). Perkins noted, however, that *X. sonorina*'s fondness for breeding in dead logs on the sea-beaches might have enabled it to reach the islands by natural immigration. Blackburn and Kirby (1880) noted *X. sonorina* as a common South American insect that was common near Honolulu and elsewhere. Hawaii has a total of 11 non-native bee species (Tenorio and Nishida 1995).

The main concerns regarding bees in general, especially *A. mellifera*, are bee attacks and the possibility of a severe allergic reaction to bee stings or anaphylactic shock. The severity of reactions to bee stings varies widely among individuals from localized pain and swelling to the serious and sometimes fatal, systemic reaction (Komatsu 1982). *Xylocopa sonorina* is rarely a serious public health concern due to its relatively shy behavior despite its formidable appearance (Nishida and Tenorio 1993). In addition, bee nesting in the structure of a home can increase stinging hazards as well as lead to damage to the home. *Apis mellifera* hives in wall voids can melt and leak wax and honey, and *X. sonorina* may bore into walls, eaves and structural beams.

This is one of a series of six related papers submitted for publication in the *Proceedings of the Hawaiian Entomological Society*.

Materials and Methods

Study area. Oahu is the third largest and most populous of the Hawaiian Islands. It is home to ~900,000 people, has a highly urbanized southern coast, and extensive growth has recently occurred in the central and Ewa Plains areas of the island. Oahu's climate is characterized by a two-season year, mild and fairly uniform temperature conditions, striking marked geographic differences in rainfall, and a general dominance of trade-wind flow. For a more detailed description of the area of study, see Leong and Grace (2009) or Leong (2008).

Study methods. A comprehensive arthropod pest data set was extracted from Hawaii State Department of Health Vector Control Branch inspection reports from 1990 to 1999. Population data were obtained from Hawaii Census 1990 and 2000 and The State of Hawaii Data Books from 1990 to 2004. The Vector Control inspection reports were reviewed and compiled into general pest categories using the reported problem on the original complaint. All together, a total of 8,936 individual pest problems were found from which 27 pest categories plus a miscellaneous category were obtained. One-hundred twenty-five district/

area geographic locations with varying populations were established using community structure, geographic features and inspection report designations, and the raw pest occurrence data for each district/area were standardized by dividing by the estimated population and multiplying the decimal number generated by 10,000. District/areas with populations of less than 500 were excluded from occurrence analysis. The resulting transformed pest occurrence data were mapped on a traditional four-season basis using ArcView GIS 3.2 to create 40 maps for each of 10 major pest categories along with four additional maps each showing cumulative seasonal activity. Pest occurrence was graphically compared within and between district/areas, and pest occurrence and distribution were correlated with season. Finally, pest occurrence and distribution were evaluated using inspection data, including species identifications. See Leong and Grace (2009) or Leong (2008) for a more complete description of methods.

Results

Bee activity during the winter of 1990 included only one district/area with very light problems (1–3 complaints) each in the south and lower east areas of the island, and one light peak (4–8 complaints) occurring in Maunawili in east Oahu. In winter 1991, very light bee activity was present in south and lower east Oahu with light activity occurring in Olomana-Pohakupu on the east side. Overall bee activity was nearly half as compared to the preceding fall. Bee activity in winter 1992 was very light in south and lower east Oahu with a light peak occurring in Mahinui-Kokokahi on the east coast. Overall activity was a sixth of that in the fall of 1991. Winter 1993 bee activity was much reduced at less than one-sixth of that in fall 1992. Light activity was found only in Kaaawa on the east coast. Bee activity in the winter of 1994 only occurred in south Oahu with a light peak in Kakaako and was, again, reduced from that in the fall. Activity decreased by well over 50%. The winter of 1995 saw a reduction in bee activity to less than one-eighth of the previous fall. Activity was very light and only occurred in south Oahu. No bee activity was reported in the winter of 1996. Overall bee activity in winter 1997 was nearly one-fourth of fall 1996 activity, and only occurred in south and east Oahu district/areas. Light peaks were found in Kalihi Kai in the south and Olomana-Pohakupu on the east coast. Bee activity in winter 1998 was very light with only a single district/area, Waialua on the north shore, being affected. Finally, as in the previous year, bee activity in the winter of 1999 was very light with only a single district/area being affected. Kailua on the east coast of Oahu reported the bee activity.

Spring 1990 bee activity was found mostly along the central, south and lower east district/areas of Oahu, and was about four times as that in the winter. Light peaks in activity occurred in Olomana-Pohakupu and Yacht Club Knolls-Terrace on the east side. Bee activity had a noticeably lower increase in spring 1991 with activity mainly occurring in south and lower east Oahu. A light peak occurred in Lanikai on the east coast. In spring 1992, bee activity about doubled from in the winter, but remained very light and occurred only in south and lower east district/areas. Bee activity increased lightly in spring 1993 with the activity being found only in south, lower east and central Oahu. A moderate peak (9–15 complaints) was found in Makiki Heights-Tantalus. Overall spring 1994 bee activity was comparable to that in the previous winter. Very light activity was found only in south and lower east district/areas of the island. Bee activity in spring 1995 substantially increased in occurrence and intensity over the winter activity. Activity peaked lightly in Oneawa Hills-Aikahi Park on the east coast and in Whitmore Village in central Oahu, and a moderate spike was found in the east district/area of Maunawili. Spring 1996 bee activity was fairly well distributed across central, south and lower east Oahu. Activity peaked lightly in Waimanalo on the

east side of the island. The bee activity in spring 1997 was about twice that in the winter. Moderate peaks in bee activity occurred in Kalani Valley in south Oahu and Kahe Point-Honokai Hale on the west shore. Bee activity in spring 1998 was well over 10 times that of in the winter. Light bee activity was found in Kahuku along the east coast and in Wahiawa in central Oahu. Lastly, spring 1999 bee activity was found mainly in south Oahu from Pearl Harbor-Hickam Air Force Base to Kakaako with a light peak occurring in Kakaako.

The number of district/areas reporting bee activity in summer 1990 was nearly half that in the spring with activity mainly occurring in south and lower east Oahu. A light peak was found in the east district/area of Olomana-Pohakupu. The level of bee activity in summer 1991 increased in intensity from in the spring and occurred mainly in south and east Oahu. There were light peaks in Kakaako on the south shore, and in Waimanalo and Kaaawa on the east side of the island. A moderate spike occurred in the east district/area of Heeia Kea. Bee activity in the summer of 1992 increased noticeably in occurrence and intensity in east Oahu. Light activity was found in Waimanalo, Olomana-Pohakupu and Hauula on the east side along with a moderate peak in Maunawili and a heavy spike (16–24 complaints) in Heeia Kea. Summer 1993 bee activity increased slightly over that of in the spring, and occurred in the south and lower east district/areas. Light activity was found in Waialae Nui in south Oahu, and in Olomana-Pohakupu and Heeia Kea on the east side of the island. Summer 1994 showed increased bee activity by almost three times that in the spring. There was a light peak in activity in Royal Summit in central Oahu, activity mainly occurred in south and lower east district/areas. Summer 1995 bee activity showed an increase overall. Activity peaked lightly in Downtown in the south and Waimanalo on the east side. Moderate spikes occurred in Olomana-Pohakupu and Waiahole-Waikane in east Oahu, and in Mokuleia on the north shore. As in the spring, bee activity in summer 1996 was found in central, south and lower east district/areas. Activity decreased in central and south Oahu, and increased on the east side of the island. Bee activity peaked lightly in Moanalua Valley in the south and Maunawili in east Oahu, and a moderate spike occurred in Olomana-Pohakupu. Summer 1997 bee activity also decreased in central and south Oahu, and increased on the east side of the island. Light peaks in activity occurred in Moanalua Valley and Portlock in the south, and in Olomana-Pohakupu, Mahinui-Kokokahi, Heeia Kea and Kahuku along the east side of the island. The bee activity in the summer of 1998 increased from that in the spring and was mainly found in the central, south and lower east district/areas of the island. Light peaks in activity occurred in Halawa Valley in central Oahu, Mariners Ridge in the south, and Olomana-Pohakupu on the east side of Oahu. Bee activity declined in summer 1999 leaving, except for a cluster of three very light sites from Downtown to Nuuanu-Dowsett Highlands in the south, a few widely spaced district/areas that reported activity. A light peak occurred in Kahuku on the east coast, and there was no reported bee activity on the north shore or along the west side of Oahu.

In the fall of 1990, bee activity remained similar overall to that in the summer with most of the activity being found in the south and lower east district/areas of the island. There was a moderate peak in Kakaako. During the fall of 1991, the bee activity increased noticeably with activity concentrated from Kakaako to Wilhelmina Rise-Maunalani Heights in south Oahu and Lanikai to Kahaluu-Waihee Valley on the lower east side of the island. Light peaks were found in the central district/area of Royal Summit, in Kakaako, and in Lanikai, Olomana-Pohakupu, Maunawili and Heeia Kea in east Oahu. The bee activity in fall 1992 was comparable in occurrence and distribution to that of in the summer. There was a cluster of activity from Kakaako to Nuuanu-Dowsett Highlands in south Oahu and a concentration in activity from Lanikai to Kahaluu-Waihee Valley on the east side. Light peaks were found in Portlock on the south shore, and in Lanikai, Olomana-Pohakupu, Oneawa-Aikahi Park, Yacht Club Knolls and Terrace, and Ahuimanu on the lower east side

of the island. Moderate spikes in bee activity were present in Kakaako and in Punaluu on the east coast. Fall 1993 saw a slight overall increase in bee activity and distribution. There was a light peak in Yacht Club Knolls and Terrace. Overall bee activity about doubled in the fall of 1994 with concentrations in activity appearing from Downtown to Saint Louis Heights in south Oahu and Lanikai to Oneawa-Aikahi Park on the east side. Light peaks in bee activity were found in Lanikai and Olomana-Pohakupu in east Oahu and a very heavy spike (25–35 complaints) was recorded in the central district/area of Kunia. There was an overall increase in bee activity in fall 1995 with activity decreasing on the north shore and increasing in south Oahu. Light peaks in activity were found in the area of Sunset Beach on the north shore; Moanalua Valley, Downtown and Manoa-Woodlawn in south Oahu; Olomana-Pohakupu, Maunawili and Kahuku on the east side of the island; and the central district/area of West Loch Estates. There was a moderate spike in Makiki Heights-Tantalus, and bee activity was highest from Moanalua Valley to Manoa-Woodlawn in the south and in lower east Oahu. In fall 1996, bee activity increased in south and east Oahu as well as on the north shore. Activity on the windward side of the island was mainly in the lower east district/areas. Light peaks were found in the Sunset Beach area and Waialua on the north shore; in Red Hill in south Oahu; and in Olomana-Pohakupu, Mahinui-Kokokahi, Heeia Kea and Kahuku on the east side of the island. A single moderate spike occurred in the south district/area of Halawa Valley. An overall increase in bee activity occurred in the fall of 1997. Activity was mainly found from Kalihi Valley to Waialae Iki in south Oahu and from Olomana-Pohakupu to Heeia Kea on the lower east side of the island. Light peaks occurred in the south district/area of Nuuanu-Dowsett Highlands, and in Olomana-Pohakupu, Maunawili, Yacht Club Knolls and Terrace, and Heeia Kea in east Oahu. In fall 1998, bee activity decreased from that of in the summer, and remained mostly in south and lower east district/areas. Light peaks occurred in Foster Village and Moanalua Valley in south Oahu, and in Maunawili on the east side of the island. Bee activity in fall 1999 decreased by well over 50% from that in the summer. Very light activity was found only in McCully-Moiliili in south Oahu and in Heeia on the lower east coast.

Reported bee activity was found mostly within the central, south and east urban districts (Figures 1A–D). The eastern half of south Oahu and the southern half of the east districts showed the highest number of complaints. The levels of bee activity were highest during the spring, summer and fall, and there were bee problems around the airport throughout the year. However, the major ports of entry, Honolulu International Airport, Sand Island and Campbell Industrial Park, could not be evaluated by adjusting for population due to their low residential population.

Discussion

The primary bee species recorded was *Apis mellifera* (~96.8%; $n = 666$), the honey bee (Table 1). A few *Xylocopa sonorina* (~3.2%), Sonoran carpenter bee, cases were also recorded. The main sources of bee problems were *A. mellifera* swarms, and bee hives established in urban areas from wild or domestic hives, and, in the case of carpenter bees, bees burrowing into the eaves of homes or in dead wood on the premises.

Hawaii has more than 160 beekeepers, including 15 commercial operations (Dicus 2007a). On Oahu, managed hives were present in Manoa, Makiki Heights, Round Top, Tantalus, Whitmore Village, Nanakuli, Waimanalo, and Punaluu and near Kahuku (Dicus 2007b, Dicus 2007c, Dicus 2007d). Among many other locations, a colony was also present in Diamond Head crater. The concentration in *A. mellifera* activity in the eastern half of south Oahu and the southern half of the east districts was probably partly due to the presence of these hives, but was mainly due to the fact that the colonies that were originally placed in

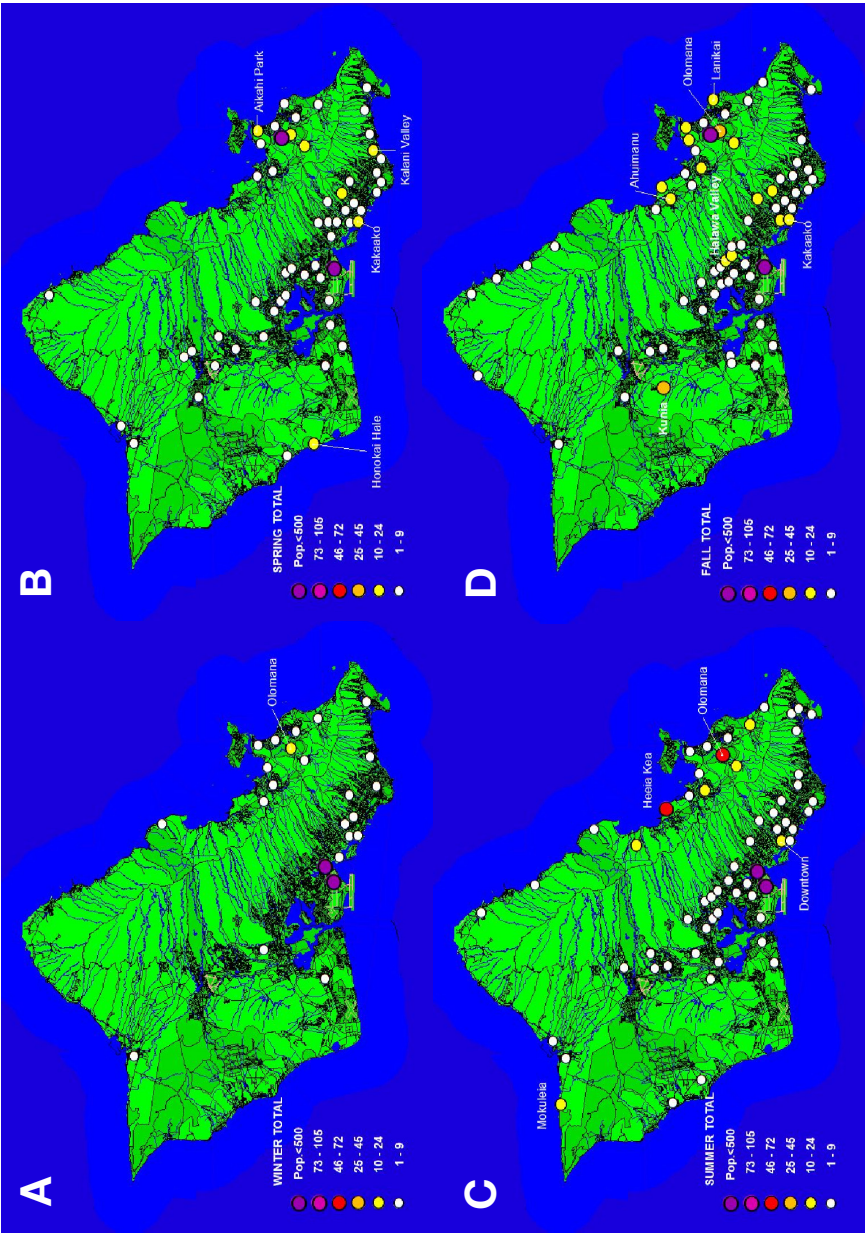


Figure 1. Bees, seasonal totals (1990–1999) for winter (A), spring (B), summer (C) and fall (D).

Table 1. Bee species occurrence as determined by a sampling of 716 bee-related inspection reports.

Species	%	Mean	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
<i>Apis mellifera</i>	96.8	64.5	45	51	82	43	42	115	102	77	65	23	645
<i>Xylocopa sonorina</i>	3.2	2.1	8	2	1	0	1	4	2	1	1	1	21
Total	100.0	66.6	53	53	83	43	43	119	104	78	66	24	666

Nuuanu Valley in 1857 eventually hived off and established feral colonies in the surrounding forests (Roddy and Arita-Tsutsumi 1997). Subsequent *A. mellifera* introductions hived off as well such that feral colonies of both the German and Italian honey bee strains are common in the wild, and swarms from these hives as well as domestic hives regularly find their way into urban areas. Perkins (1913) reported *X. sonorina* to be an injurious species “since it does considerable damage by riddling fence-posts, telephone poles and other wood with its borings.” It also burrows in the dead or nearly dead parts of living trees. This is still true today with damage mainly occurring in fences, walls, eaves and structural beams built with soft woods.

This survey has determined that bee activity regularly occurs in urban areas as a result of past and present human activities. As a result, injury from bee stings is possible, especially in the eastern half of south Oahu and the southern half of the east districts during the spring, summer and fall months when swarming activity is highest. The results indicate that community or island-wide educational programs should be carried out in late winter to remind the public that bee season is approaching, and that residential bee surveys may be concentrated in a limited number of district/areas according to bee complaints received. Educational activities are currently conducted only on a limited basis during inspections, and direct intervention in the form of treatment and removal of an *A. mellifera* swarm or hive may be carried out if a public health threat is present. Small area or neighborhood bee surveys have confirmed the practicality of using small-target area surveys since a single *A. mellifera* swarm or hive is normally found in any given area, and *X. sonorina* nests are usually restricted to the problem site reported. As pointed out earlier, there are bee problems around the airport throughout the year. The bees involved were *A. mellifera*. Fortunately, abatement response for these problems was immediate so that they posed a limited public health concern. However, considering the visitor, workforce and heavy machinery activity, the potential for a serious bee problem will always be present.

The varroa mite, *Varroa destructor*, a serious pest of *A. mellifera*, was recently detected on Oahu (Ramadan et al. 2008). Severe infestations of this mite will eventually result in a decline in bee colonies. The presence of the varroa mite on the island will surely reduce the occurrence of bee activity and likely the distribution as well.

Geographic analysis can help to target areas and

times of the year for more efficient application of bee prevention, control and education programs by continuously tracking bee activity using Vector Control inspection reports. Improvements in methodology include using the actual number of complaints within a district/area and the severity of the bee infestation found together with data adjusted for population to more accurately determine the need for targeted survey, abatement and education efforts. For example, geographic analysis of transformed bee occurrence may flag a potential problem district/area for increased scrutiny, but additional action would be taken only if at least three complaints were received, the level of infestation was heavy and/or the bee problem was found to occur over an extensive area. The same deciding factors may be applied directly for the excluded district/areas with resident populations of less than 500.

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